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APOLLO SOYUZ TEST PROJECT
G&N ERROR ANALYSIS
(CM 111/IMU 25)

by

S. B. Helfant

June 1975



The Charles Stark Draper Laboratory, Inc.

Cambridge, Massachusetts 02139

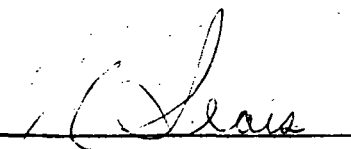
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N. Sears

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This volume is the combined effort of the following additional people: Linda Willy prepared the component performance tabulation and performed the plotting for the inertial components. William Beaton provided the failure rates for the success probability. Their contribution to the preparation of this volume is greatly appreciated.

The publication of this report does not constitute approval by the National Aeronautics and Space Administration of the findings or the conclusions contained herein. It is published only for the exchange and stimulation of ideas.

ABSTRACT

This document presents data on G&N system performance and operation for the CM. For data on the effects of Block II and of measured CM IMU test data deviation uncertainties on earth orbit insertion indication uncertainties and on deorbit burn and reentry uncertainties, the reader is referred to E-2760, the G&N error analysis report for Skylab 2).

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GYRO DRIFT TEST POSITIONS
FOR
SUNDANCE, LUMINARY, COLOSSUS, AND ON

STABLE MEMBER POSITION	STABLE MEMBER ORIENTATION	HORIZONTAL DRIFT	VERTICAL DRIFT
1	X DOWN Y SOUTH Z WEST	NBDY-ADOAY	
2	X DOWN Y WEST Z NORTH	+NBDZ-ADOAZ	-NBDZ+ADIAZ
3	X SOUTH Y WEST Z DOWN	NBDX-ADOAX	
4	X EAST Y SOUTH Z DOWN	+NBDY+ADSRAZ	+NBDZ+ADIAZ
5*	X WEST Y UP Z NORTH	+NBDZ-ADSRAZ	
6*	X SOUTH Y DOWN Z EAST	+NBDX+ADSRAZ	-NBDY+ADIAZ
7	X NORTH Y UP-WEST Z UP-EAST	-NBDX+(ADSRAZ/ $\sqrt{2}$)	
8	X EAST Y UP-NORTH Z UP-SOUTH	$(-NBDZ-NBDY)/\sqrt{2}$ +(ADIAZ-ADIAZ)/2 +(ADSRAZ+ADSRAZ)/2	
9	X UP-EAST Y UP-WEST Z SOUTH	-NBDZ+(ADSRAZ/ $\sqrt{2}$)	
10	X UP-NORTH Y UP-SOUTH Z EAST	$(NBDY-NBDX)/\sqrt{2}$ +(ADIAZ-ADIAZ)/2 +ADSRAZ/2	
11	X NORTH Y WEST Z UP	-NBDX-ADOAX	
12	X UP Y SOUTH Z EAST	+NBDY+ADOAY	
13	X UP Y EAST Z NORTH	+NBDZ+ADOAZ	

* Positions 5 and 6 are lab test only.

G&N MISSION RELIABILITY ANALYSIS

Failure rates used were obtained, for the most part, from observed Apollo field and flight experience of the PGNS. Each reported failure was analyzed with respect to its likelihood of occurrence in flight and the impact on the Mission should such failure occur. The result was to count only those reported failures which could occur in flight and which would degrade the Mission, should they occur.

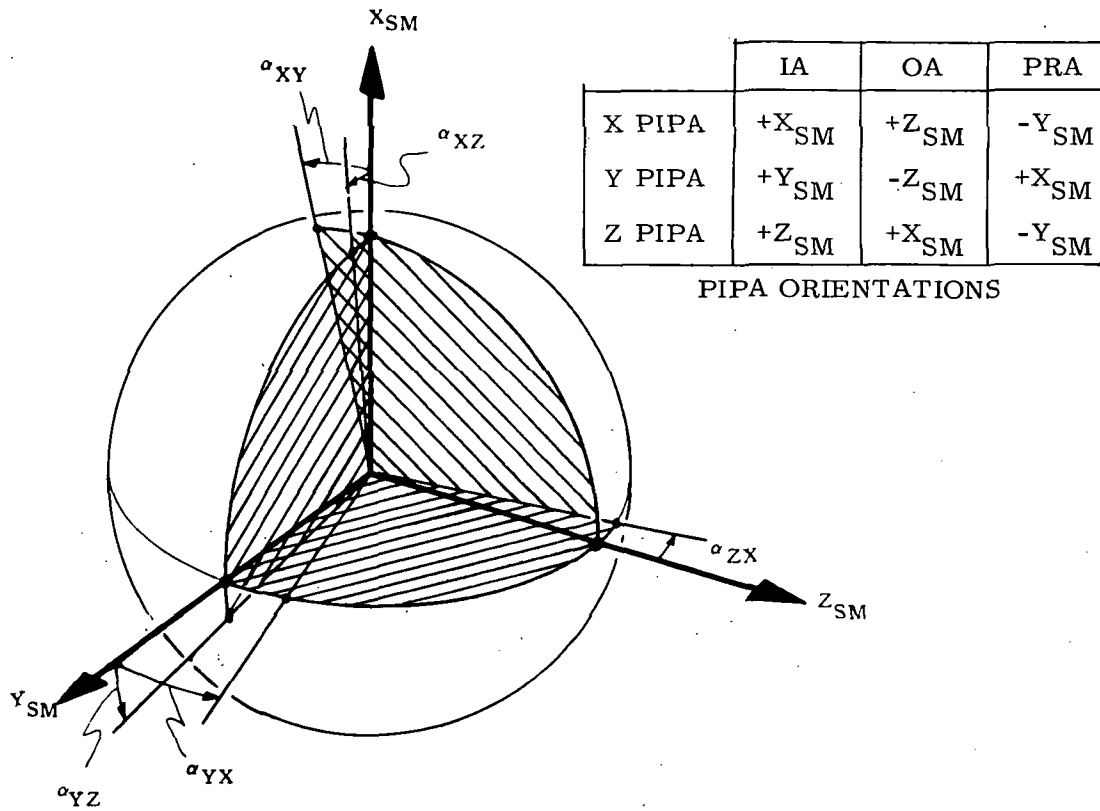
SUBSYSTEM	MODE (time/cycles)	FAILURE RATE ($\lambda \times 10^6$)	MISSION DURATION (hrs or cycles)	$e^{-\lambda t}$
AGC	Operate	19.2	218	0.99582
	Calendar	2.8	218	0.99939
	Envirn	30.9	0.2	0.99999
	On/Off	238.1	0	1.00000
DSKY*	Operate	1.4	218	0.99999
	Calendar	0.9	218	0.99999
	Envirn.	122.9	0.2	0.99999
	On/Off	1190.5	0	1.00000
IMU CDU**	Operate	20.2	218	0.99561
	Calendar	2.4	218	0.99948
	Envirn	62.5	0.2	0.99999
	On/Off	1666.6	0	1.00000
IMU	Operate	94.1	218	0.97969
	Calendar	2.6	218	0.99943
	Envirn	18.5	0.2	0.99999
	On/Off	142.9	0	1.00000
IMU Electronics (PSA)	Operate	8.4	218	0.99817
	Calendar	1.2	218	0.99974
	Envirn	18.5	0.2	0.99999
	On/Off	714.3	0	1.00000
Optics Assembly	Operate	119.3	218	0.97433
	Calendar	1.8	218	0.99961
	Envirn	18.5	0.2	0.99999
	On/Off	238.1	0	1.00000
Optics Electronics	Operate	17.2	218	0.99626
	Calendar	7.1	218	0.99845
	Envirn	18.5	0.2	0.99999
	On/Off	142.9	0	1.00000

G&N MISSION RELIABILITY

CM = 0.93736

*Considers parallel redundancy $(1 - (1 - e^{-\lambda t})^2)$

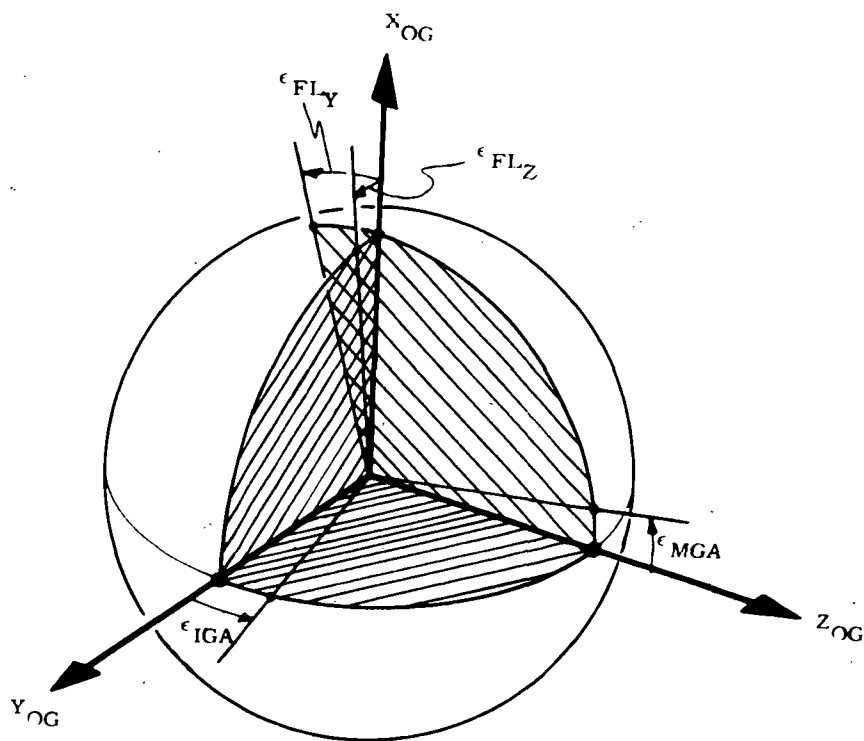
**Includes CM Optics CDU



PIPA Misalignments from Ideal Stable Member Axes

Term	(Angle in $\widehat{\text{Sec}}$)
	CM-IMU 25
α_{XY}	+ 24
α_{XZ}	+ 7
α_{YZ}	+ 6
α_{YX}	- 14
α_{ZX}	+ 3

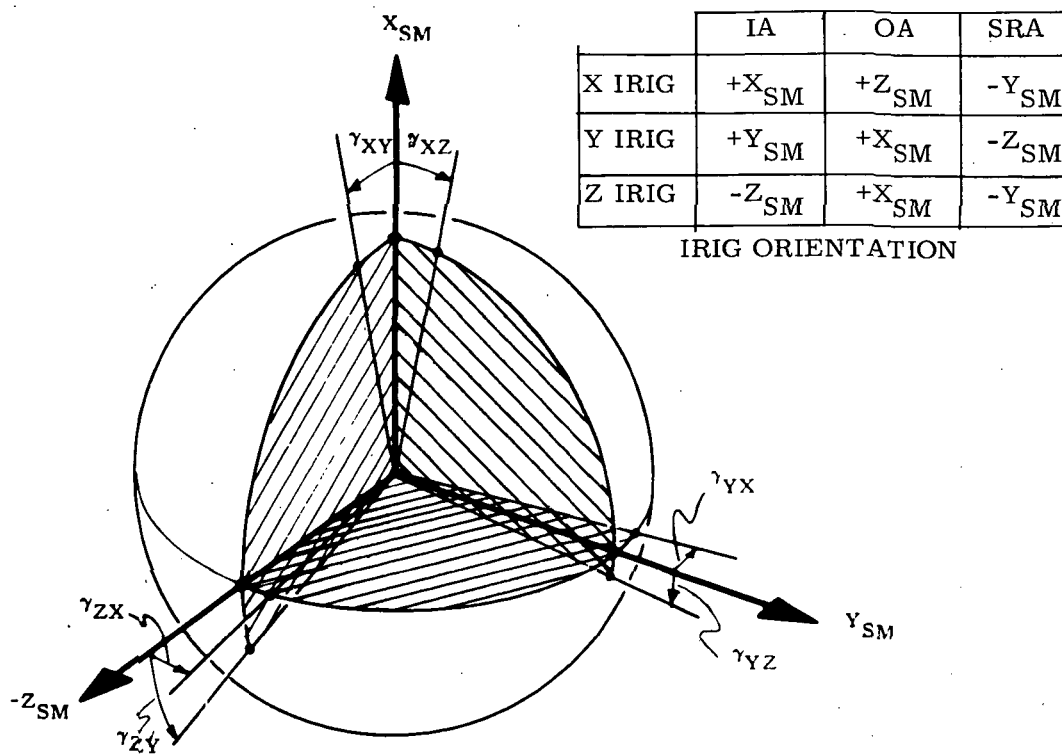
DEFINITION OF POSITIVE SENSE
PIPA INPUT-AXIS MISALIGNMENTS
with respect to
IDEAL STABLE MEMBER AXES



Gimbal Axis Orthogonality Errors and Outer Gimbal Misalignment from Casemounting Axes

Term	(Angle in Sec) CM-IMU 25
ϵ_{IGA}	+ 6
ϵ_{MGA}	- 20
ϵ_{FLY}	- 1
ϵ_{FLZ}	- 9

DEFINITION OF POSITIVE SENSE
GIMBAL AXIS ORTHOGONALITY
and
OUTER GIMBAL ALIGNMENT
with respect to
CASE MOUNTING ALIGNMENT



IRIG Misalignments from Ideal Stable Member Axes

Term	(Angle in Sec) CM-IMU 25
γ_{XY}	- 46
γ_{XZ}	+ 2
γ_{YZ}	+ 50
γ_{YX}	+ 106
γ_{ZX}	- 145
γ_{ZY}	+ 16

Block II G&N
DEFINITION OF POSITIVE SENSE
IRIG INPUT-AXIS MISALIGNMENTS
with respect to
IDEAL STABLE MEMBER AXES

IMU S/N 25
CM 111/G&N 215

IRIGs

X = 8A128

Y = 8A121

Z = 8A120

PIPA's

X = 2AP110R

Y = 2AP276

Z = 2AP282

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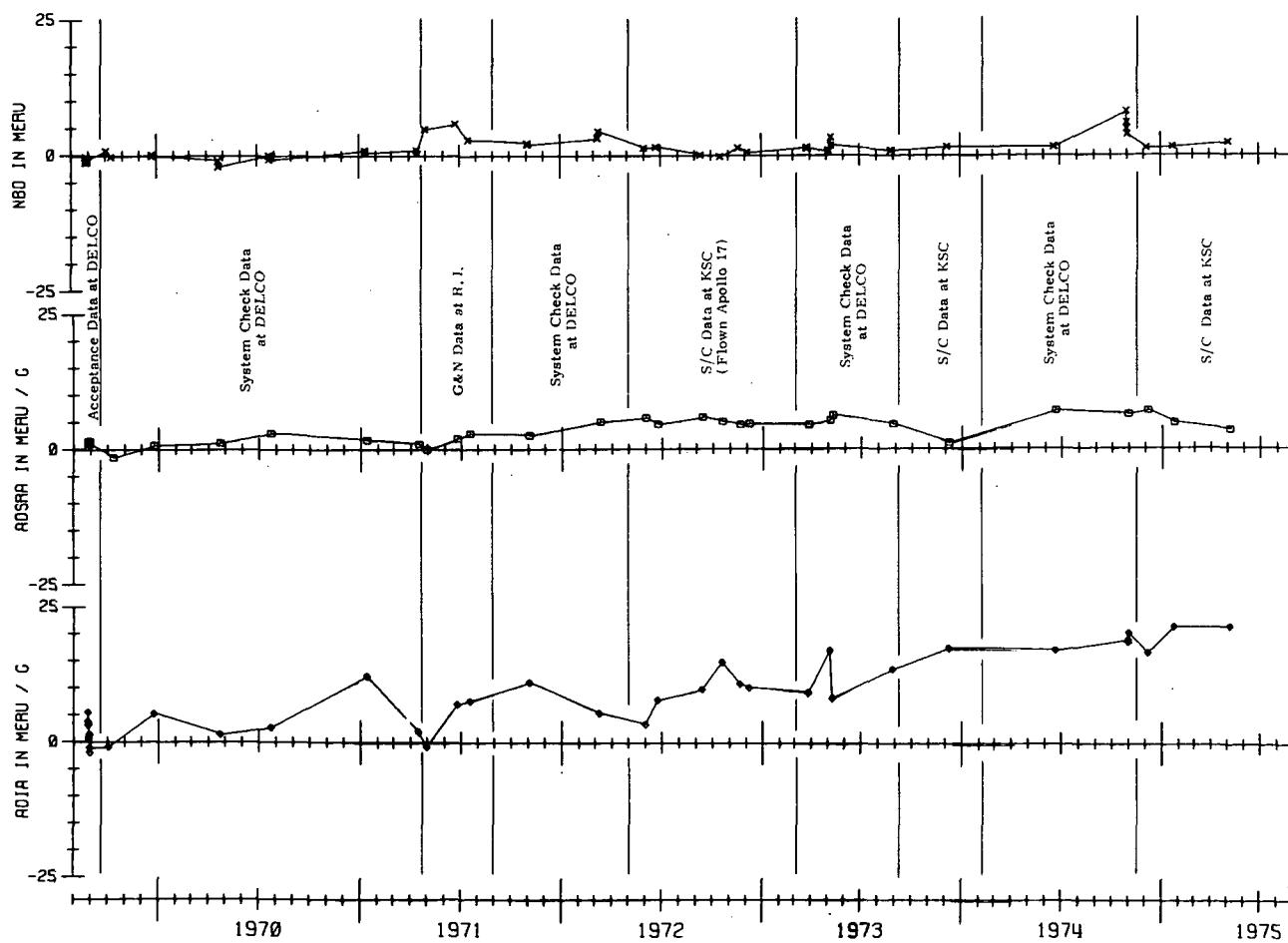
DATE	LOC	TST IMU TYP ASSN	GEN SYS	VRD	ADSR	ADIA	DELSF+ DELSF-	WHEEL RDT HOURS	I+	I-	ID	ADDA
5AU69	A41	CSS						C102				
5AU69	A41	CSS						C 99				
6AU69	SG R3.7,	67.6,	49.9	TG 54.7,	68.8,	49.9					- 8.5	
12AU69	A43	CSS						144			- 7.3	
14AU69	A43	CSS						142				
15AU69	A43	CSS						144			- 9.5	
21AU69	COMP SELECT											
21AU69	A43	CSS					96 - 175	143	85.011	85.009		
22AU69	COMP VERIP						151 - 161		85.010	85.008		
22AU69	A43	CSS					165 - 175	140	85.011	85.008		
22AU69	DEMO	T/F = 1210.08										
22AU69	A43	CSS										
25AU69	VIR	IA ALIGN = +0.65										
26AU69	A43	CA1			1.5	5.5						
26AU69	A43	CA2			0.9	3.8	172 - 250	143	85.009	85.007	- 7.3	
26AU69	A43	CA3			1.2	3.1						
27AU69	A43	CB1			1.1	3.6						
27AU69	A43	CB2			1.4	0.8	124 - 130	142	85.001	85.007	- 8.1	
27AU69	A43	CB3			1.0	0.6						
29AU69	A43	CC1			1.2	1.4						
29AU69	A43	CC2			1.1	2.0	200 - 257	141	406	85.010	85.008	- 9.4
29AU69	A43	CC3			1.1	1.1						
2SE69	M/O TO 0814											
2SE69	UNIT INSTALLED IN IMU S/W 20-REPLACING 8A-127											
10C69	A01	SPR Y 20			0.9	- 0.9						
10C69	A01	SPR Y 20			- 0.2	- 1.5	- 27 - 194	516				1.2,
10C69	A01	SPR Y 20										
23DE69	A03	SPO Y 20			0.2	5.2						
23DE69	A03	SPO Y 20			- 0.1	0.8						0.5
30DE69	A03	SPO Y 20					- 417 - 561	763	85.006			
6JA70	GRAVITY TRANSIENT TEST, NO FLUID TRANSIENTS DETECTED.							819				
22JA70												
21AP70	A04	SPO Y 20			0.9	1.4						
21AP70	A04	SPO Y 20			- 2.0	1.2						1.3
22AP70	A04	SPO Y 20					- 227 - 274	991	85.009			
5MY70												
22JL70	A03	SPO Y 20			0.1	2.7						
22JL70	A03	SPO Y 20			- 0.7	3.0						1.3
29JL70	A03	SPO Y 20					- 107 - 150	925	85.018			
7AU70	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.							1000				
17AU70	A03	SPO Y 20										
11JA71	A03	SPO Y 20			1.0	12.3						
11JA71	A03	SPO Y 20			0.6	1.7	- 50 - 7	C115	85.019			1.3
12JA71	A03	SPO Y 20										
14AP71	A01	SPO Y 20			1.1	2.0	- 150 - 361		85.005			0.8
15AP71	A01	SPO Y 20			0.4							
21AP71	IMU S/N 20 SHIPPED FROM DELCO/HRKE TO NP.											
26AP71	IMU 20 GEN 21R INSTALLED IN CM-114.											
29AP71	NSC GEN Y 20 21R				4.9	- 0.1	- 175 - 376					
23JE71	NSC GEN Y 20 21R				5.9	2.0	- 524 - 525					

DATE	LOC	TYP	IMU	GEN	SYS	NRD	ADSPA	ADIA	DELSF+	DELSF-	WHREL	I+	I-	ID	ADDA
23JUE71	ADIA	POSITION	8												
16JUL71	NSC	GEN Y 20		2.9		2.9	2.9	3.9							
30AUG71	IMU	20 SHIPPED FROM NR TO DELCO/MKE.						7.7	-	432	-	549			
2NOV71	A03	SPO Y 20		2.3				11.2							
2NOV71	A03	SPO Y 20		2.1			2.6								1.0
3NOV71	A03	SPO Y 20										84.993			
29FEB72											1545				
8MR72	A03	SPO Y 20		3.2											
9MR72	A03	SPO Y 20		4.5			5.1	5.5							
10MR72	NO FLUID	TRANSIENT OBSERVED DURING GRAVITY TRANSCIENT TEST.										85.008			
9MY72	IMU	20 SHIPPED FROM DELCO/MKE TO KSC													
18MY72	IMU	20 INSTALLED IN CM-114 AT KSC.													
31MY72	KOB	GEN Y 20 218		1.4			5.8	3.4							1.0
31MY72	ADIA	POSITION 8						7.9							
22JUE72	KOB	GEN Y 20 218		1.6			4.6	8.0	-	306	-	349			0.5
22JUE72	ADIA	POSITION 8						3.1							
11SE72	K9A	GEN Y 20 218		0.1			5.9	10.0	-	257	-	473			1.1
11SE72	ADIA	POSITION 8						9.5				1894			
17OC72	K9A	GEN Y 20 218		-	0.2		5.1	15.1							1.2
17OC72	ADIA	POSITION 8						11.3							
18NO72	K9A	GEN Y 20 218		1.4			4.5	11.0							0.9
18NO72	ADIA	POSITION 8						8.7							
28NO72	PRE-LAUNCH	COMPENSATION: NBD= -0.1, ADIA= 13.0, ADSPA= 6.0													1.1
5DE72	K9A	GEN Y 20 218		0.6			4.7	10.3							
5DE72	ADIA	POSITION 8						15.5							
6DE72	IMU	20 GEN-218 CM-114 LAUNCHED APOLLO 17.													
7DE72															
7DE72	NBD	COMPENSATION UPDATE= 0.3 MPRU AT 23 HRS 45 MIN. GPT													
19DE72	IMU	20 GEN-218 CM-114 RECOVERED. APOLLO 17.													
12MR73	IMU	20 SHIPPED FROM NR TO DELCO/SR.													
21MR73	SB6	SPO Y 20		1.5				9.4	-	32	-	161			85.001
26MR73	SB6	SPO Y 20		1.2			4.5								
26MR73	SB6	SPO Y 20													
9AP73	UNIT	REMOVED FROM IMU-20, ASSIGNED TO IMU-25 X-POS REPL. 3040													
30AP73															
4MY73	SB5	SPO X 25		0.6				17.3							
4MY73	SB5	SPO X 25		0.9			5.3								
9MY73	SB5	SPO X 25		3.3				8.4							
9MY73	SB5	SPO X 25		1.9			6.2								
11MY73	NO FLUID	TRANSIENTS DETECTED DURING GRAVITY TPSS.													
30MY73															
24AUG73	SB6	SPO X 25		0.7				13.9	99	197					1.2
27AUG73	SB6	SPO X 25		0.9			4.6								
27AUG73	IMU	25 MOVED FROM DELCO TO KSC, SI-RESCUE VEHICLE													
12SE73	IMU	25 INSTALLED IN CM-119, GEN-213, SI-RESCUE VEHICLE													
24SE73	IMU	25 SHIPPED FROM KSC TO DELCO		1.6			1.1	17.8							1.5
07DE73	K9B	GEN X 25 213		1.6											
13FE74	IMU	25 SHIPPED FROM KSC TO DELCO		1.6				17.4	95	210	C 91				1.2
19JE74	SB6	SPO X 25		1.5			7.1								
19JE74	SB6	SPO X 25													

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DATE	LOC	TST IMU TYP ASSM	GEN SYS	NBD	ADGRA	ADIA	DELSF+ DELSF-	WHEEL RDT HOUPS	I+ I-	TD	ADJA
300C74	SB6	SPO X 25		8.1		10.4	- 354 - 124		85.002		1.7
300C74	SB6	SPO X 25		6.3		18.9					
300C74	SB6	SPO X 25		4.8	6.4						
310C74	SB6	SPO X 25		3.8		20.7		C113			
18N074	IMU	25 SHIPPED FROM DRACO TO KSC									
26N074	IMU	25 INSTALLED IN CM-111									
5DE74	KOB	GEN X 25	215	1.3	7.1	17.0	- 341 - 457				1.5
22JA75	KOB	GEN X 25	215	1.5	4.8	21.9	- 257 - 352				1.7
5MY75	K9A	GEN X 25	215	2.3	3.4	21.9	- 349 - 232				1.6
7MY75								2617			

G&N 215, CM 111, IMU 25, APOLLO IRIG 8A128, X AXIS



DRIFT PLOTTED BY TIME

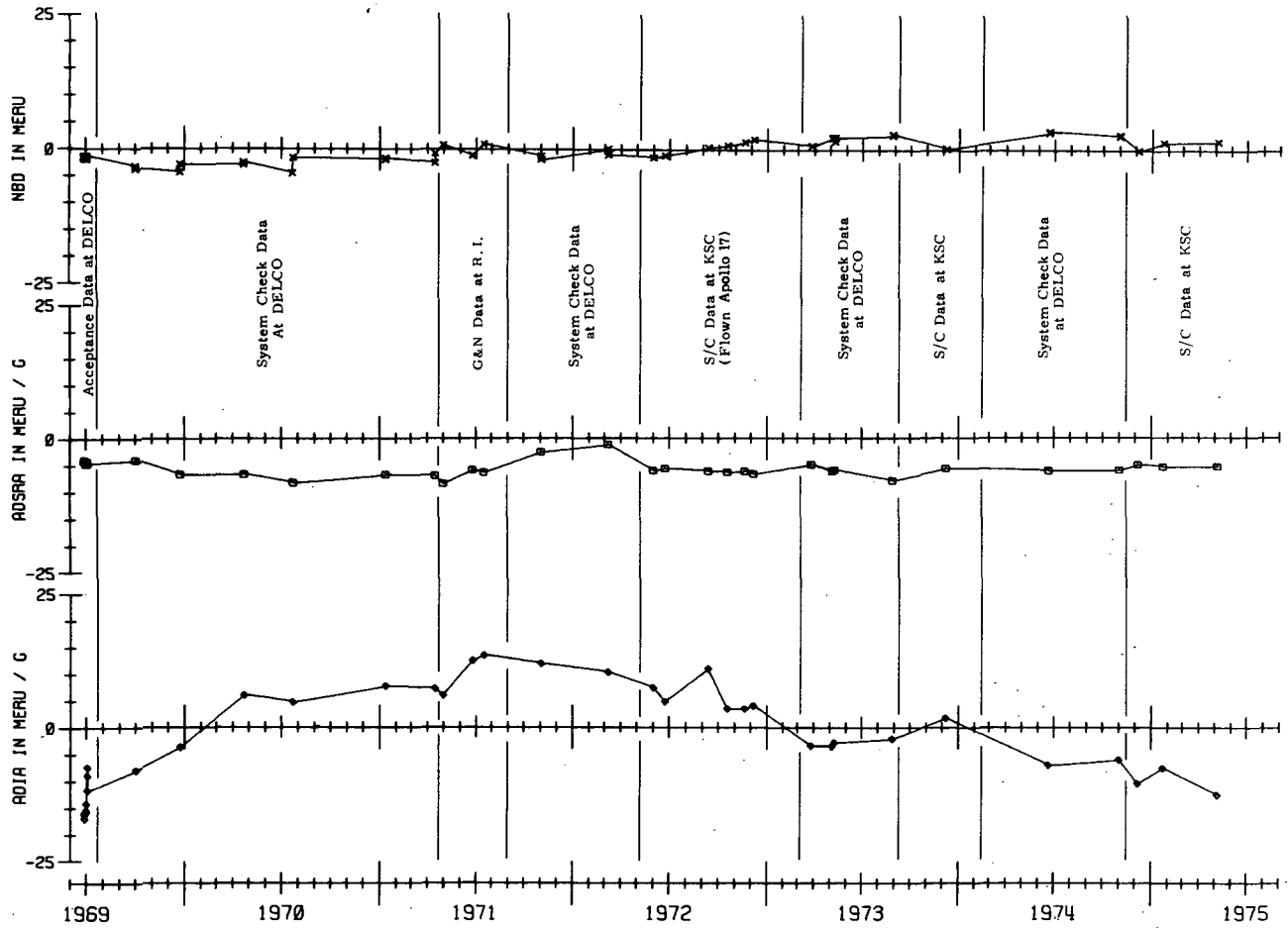
DATE	LOC	TYP	ASSN	SYS	GEN	NBD	ADSR	ADJA	DELSF+	DELSF-	WHEEL RDT HOURS	I+	I-	ID	ADJA
12JE69	A44	CSS									C104				
12JE69	A44	CSS				(- 2.1)	(- 0.4)	(- 5.5)			C106			- 5.8	
12JE69	SG 76.3				45.9	TG 50.1, 63.1, 74.5									
16JE69	A44	CSS				(- 1.5)	(- 1.7)	(- 0.7)			150			- 5.9	
19JE69	A44	CSS				(- 1.9)	(- 1.7)	(- 3.2)			149			- 5.9	
20JE69	A44	CSS									144				
24JE69	COMP	SELFCT							82	13	154	85.009	85.009		
24JE69	A44	CSS													
25JE69	COMP	VERIF							86	24		85.013	85.015		
25JE69	A44	CSS													
26JE69	DEMO	T/F			1109.8	/ LOW RDT 2 EXTRA RDT'S TAKEN			70	79	132	85.014	85.016		
26JE69	A44	CSS									143				
26JE69	A44	CSS									145				
27JE69	VIB	TA				ALIGN = -0.4,									
27JE69	A44	CA1				- 1.9	- 4.2	- 16.0							
27JE69	A44	CA2				- 1.5	- 4.2	- 16.2	514	451	149	85.017	85.019	- 6.1	
27JE69	A44	CA3				- 1.4	- 4.2	- 17.0							
30JE69	A44	CB1				- 1.8	- 4.2	- 14.2							
30JE69	A44	CB2				- 1.4	- 4.7	- 15.7	635	519	149	85.025	85.022	- 5.5	
30JE69	A44	CB3				- 1.8	- 4.2	- 15.5							
23JL69	A44	CC1				- 1.6	- 4.7	- 7.4							
23JL69	A44	CC2				- 2.0	- 4.3	- 9.0	372	550	153	85.012	85.014	- 6.8	
23JL69	A44	CC3				- 1.4	- 4.6	- 11.8							
16JL69	RDT	RMS				DEV = 5.9 CCS / ACCEPTED ON FAIVER C1263 M/3 TO 0814									
28AU69	UNIT	INSTALLED				IN IMU S/N 20, REPLACING 7A-134									
10C69	A01	SPR	X 20			- 3.3	- 4.0								1.7
10C69	A01	SPR	X 20			- 3.8	- 8.0								
100C69	A01	SPR	X 20						27	427	537				
23DE69	A03	SPO	X 20			- 4.4	- 3.7								
23DE69	A03	SPO	X 20			- 2.9	- 6.7								1.9
30DE69	A03	SPO	X 20						- 441	7	787	85.006			
6JA70	GRAVITY	TRANSIENT	TEST, NO FLUID TRANSIENTS DETECTED.								843				
22JA70															
21AP70	A04	SPO	X 20			- 3.0		6.0							1.5
21AP70	A04	SPO	X 20			- 2.6	- 6.7								
22AP70	A04	SPO	X 20						- 294	50	915	85.009			
5NY70															
21JL70	A03	SPO	X 20			- 4.6		4.7							
22JL70	A03	SPO	X 20			- 1.7	- 8.3								2.3
29JL70	A03	SPO	X 20						27	451	950	85.019			
7AU70	NO FLUID	TRANSIENTS	DETECTED DURING GRAVITY TRANSIENT TPST.								1024				
17AU70	A03	SPO	X 20												
11JA71	A03	SPO	X 20			- 2.0		7.7							2.2
11JA71	A03	SPO	X 20			- 1.8	- 6.8								
12JA71	A03	SPO	X 20						50	461	85.019				
14AP71	A01	SPO	X 20			- 2.6		7.2							
14AP71	A01	SPO	X 20			- 0.8	- 7.0								1.3
15AP71	A01	SPO	X 20						- 174	240		85.003			
21AP71	IMU	S/N 20	SHIPPED FROM DELCO/MAKE TO NP.												

DATE	LOC	TST IMU TYP ASSN	GEN SYS	NBD	ADSRA	ADIA	DELSF+ DELSP-	WHEEL RDT HOURS	I+	I-	ID	ADOA
26AP71	IMU 20	GEN 218	INSTALLED IN CM-114.									
29AP71	NSC GEN X 20	218	0.7	- 8.5	6.9	- 287	- 213					
23JE71	NSC GEN X 20	218	- 1.2	- 5.9	12.5	- 384	- 340					
16JL71	NSC GEN X 20		0.9	- 6.4	13.5	- 432	- 381					
30AU71	IMU 20	SHIPPED FROM NR TO DELCO/MKF.			11.9							
1NO71	A03 SPO X 20		- 1.3									0.7
1NO71	A03 SPO X 20		- 1.9	- 2.6				1569	84.999			
3NO71	A03 SPO X 20											
29FE72												
7MR72	A03 SPO X 20		0.1		10.3							
7MR72	A03 SPO X 20		- 1.0	- 1.2	17	361						
30MR72	NO FLUID TRANSIENT OBSERVED DURING GRAVITY TRANSIENT TEST.											
9MY72	IMU-20	SHIPPED FROM DELCO/MKF TO KSC										
18MY72	IMU-20	INSTALLED IN CM-114 AT KSC.										
31MY72	K08 GEN X 20	218	- 1.5	- 6.1	7.4							3.1
22JE72	K08 GEN X 20	218	- 1.1	- 5.7	4.8	- 150	- 75					3.2
11SE72	K9A GEN X 20	218	0.4	- 6.2	11.0	- 213	114	1918				3.1
17OC72	K9A GEN X 20	218	0.8	- 6.4	3.5							2.9
18NO72	K9A GEN X 20	218	1.4	- 6.2	3.5							2.6
28NO72	PRE-LAUNCH COMPENSATION: NBD= 0.6 ADIA= 7.0 ADSRA= -6.0											
5DE72	K9A GEN X 20	218	1.9	- 6.7	4.1							2.7
6DE72	IMU-20	GEN-218 CP-114 LAUNCHED APOLLO 17.										
7DE72												
7DE72	NBD	COMPENSATION UPDATE= 2.0 MERU AT 23 HRS 45 MIN. GET						2315				
19DE72	IMU-20	GEN-218 CM-114 RECOVERED. APOLLO 17.										
12MR73	IMU-20	SHIPPED FROM NR TO DELCO/SB.										
21MR73	SB6 SPO X 20		0.7	- 3.4	- 91	488			85.001			
26MR73	SB6 SPO X 20		0.7	- 4.9								
26MR73	SB6 SPO X 20											
9AP73	UNIT	REMOVED FROM IMU-20, ASSIGNED TO IMU-25 Y-POS REPL. 9014						2092				
30AP73												
4MY73	SB5 SPO Y 25		2.2	- 3.6	- 313							
4MY73	SB5 SPO Y 25		2.3	- 6.2	- 360	7			85.002			
9MY73	SB5 SPO Y 25		1.6	- 2.8								
9MY73	SB5 SPO Y 25		2.3	- 6.0								
11MY73	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TEST.											
30MY73												
24AU73	SB6 SPO Y 25		2.7	- 2.1	55	395						2.0
27AU73	SB6 SPO Y 25		2.9	- 8.0					85.004			
27AU73	SB6 SPO Y 25											
12SE73	IMU-25	MOVED FROM DELCO TO KSC, SL-RESCUE VEHICLE										
24SE73	IMU-25	INSTALLED IN CM-119, GEN-213, SL-RESCUE VEHICLE										
07DE73	K9B GEN Y 25	213	0.2	- 5.7	1.9	119	503					2.7
07DE73	POSITION 8 ADIA		0.3									
13PE74	IMU 25	SHIPPED FROM KSC TO DELCO										
20JE74	SB6 SPO Y 25		3.2	- 7.1	- 28	313	3120		85.004			1.4
20JE74	SB6 SPO Y 25		3.4	- 6.2								
31OC74	SB6 SPO Y 25		2.6	- 6.0	- 135	145			85.002			2.0
31OC74	SB6 SPO Y 25		2.8	- 6.1								
18NO74	IMU 25	SHIPPED FROM DELCO TO KSC										

NASA 8A-121

DATE	LOC	TYP	ASSN	SYS	NRD	ADSPA	ADIA	DELSF+	DELSF-	WHEEL POT HOURS	I+	I-	ID	ADCA
26NO74	TMU	25	INSTALLED	IN CM-111										
5DE74	KOB	GEN Y 25	215	-	0.1	- 5.1	- 10.5	- 370	- 34					1.6
5DE74	POSITION R	ADIA				- 6.5								
22JA75	KOB	GEN Y 25	215		1.4	- 5.5	- 7.6	- 329	20					2.4
22JA75	POSITION R	ADIA				- 6.3								2.4
5MY75	K9A	GEN Y 25	215		1.6	- 5.4	- 12.6	- 471	- 119					2.3
5MY75	POSITION R	ADIA				- 9.3								
7MY75										2641				

G&N 215, CM 111, IMU 25, APOLLO IRIG 8A121, Y AXIS



DRIFT PLOTTED BY TIME

NASA RA-120

DATE	LOC	TST IMU	GEN	NBD	ADSPA	ADIA	DELSP+	DELSP-	WHRL	Y+	I-	ID	ADDA
11JE69	A43	CSS							C110				
11JE69	A43	CSS		(- 3.5)	(- 1.3)	(- 5.3)			C118			-10.3	
12JE69	SG 83.3	69.1, 52.1	TG 54.9, 68.2, 87.5						PRP H5235				
13JE69	A41	CSS		(- 3.5)	(- 3.3)	(- 7.8)			152			- 9.9	
17JE69	A44	CSS							153				
17JE69	A44	CSS		(- 4.1)	(- 3.0)	(- 7.2)			146			-11.2	
19JE69	COMP SELECT												
19JE69	A43	CSS					155	109	136	85.011	85.008		
20JE69	COMP VERIF						37	-	33	85.011	85.009		
20JE69	A43	CSS								85.007	85.004		
23JE69	DEMO	T/P = 1221.8					65	-	69				
23JE69	A43	CSS							153				
23JE69	VIB.	VISUAL REJ./ WIRES REPAIRED & UNIT RE-ALIGNED 2 TIMES											
24JE69	RE-VIB	IA ALIGN = +1.15											
25JE69	A43	CA1		- 0.7	- 0.3	- 9.3				85.010	85.007	- 9.5	
25JE69	A43	CA2		- 1.1	- 0.1	- 8.5	-	18	144				
25JE69	A43	CA3		- 0.7	- 0.2	- 8.3							
27JE69	A43	CB1		- 0.8	- 0.3	- 9.4							
27JE69	A43	CB2		- 0.3	- 0.5	- 9.9	234	88	152	85.011	85.007	-10.5	
27JE69	A43	CB3		- 0.8	- 0.7	- 10.5							
29JE69	A43	CC1		- 0.4	- 1.0	- 11.9							
29JE69	A43	CC2		- 0.8	- 0.5	- 11.3	-	18	45	85.011	85.009	- 8.5	
29JE69	A43	CC3		- 0.9	- 0.6	- 8.6			424				
30JE69	CHANGE IN TORQUE LEVEL DURING AXIAL TRAVEL	NOT A FAILURE											
7JL69	ACCEPTED ON WAAIVER C1261 (RMS DEV. OF RDT = 6.0) M/O TO 3914												
	UNIT INSTALLED IN IMU S/N 48Z, REPLACING 7C-125						17	-	340	85.009			2.1
8AU69	A03	SPO Z 48		0.2	- 0.2	- 9.5							
8AU69	A03	SPO Z 48		0.4									
8AU69	A03	SPO Z 48							C113				
8AU69	A03	SPO Z 48							C117				
8AU69	A03	SPO Z 48							C115	483			
	UNIT REMOVED FROM IMU S/N 48, REPLACED BY 8A-125												
21AU69	UNIT REALIGNED												
28AU69	UNIT INSTALLED IN IMU S/N 20, REPLACING 7A-191												
10CC69	A01	SPR Z 20		- 1.3	-	12.2							
10CC69	A01	SPR Z 20		- 1.7	- 0.3	-	107	-	307	599			2.0
23DE69	A03	SPO Z 20		- 2.5	-	8.8							
23DE69	A03	SPO Z 20		- 1.8	- 1.5	-							
30DE69	A03	SPO Z 20					-	150	- 528	939	85.008		2.0
6JA70	GRAVITY TRANSIENT TEST, NO FLUID TRANSIENTS DETECTED.												
22JA70									896				
21AP70	A04	SPO Z 20		- 1.8	-	7.7							
21AP70	A04	SPO Z 20		- 1.6	1.7				C115				2.4
22AP70	A04	SPO Z 20					93	-	317	85.010			
5HY70									967				
22JL70	A03	SPO Z 20		- 1.8	-	7.2							
22JL70	A03	SPO Z 20		- 1.9	0.2								
29JL70	A03	SPO Z 20					260	-	127	1002	85.019		2.2
7AU70	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.												

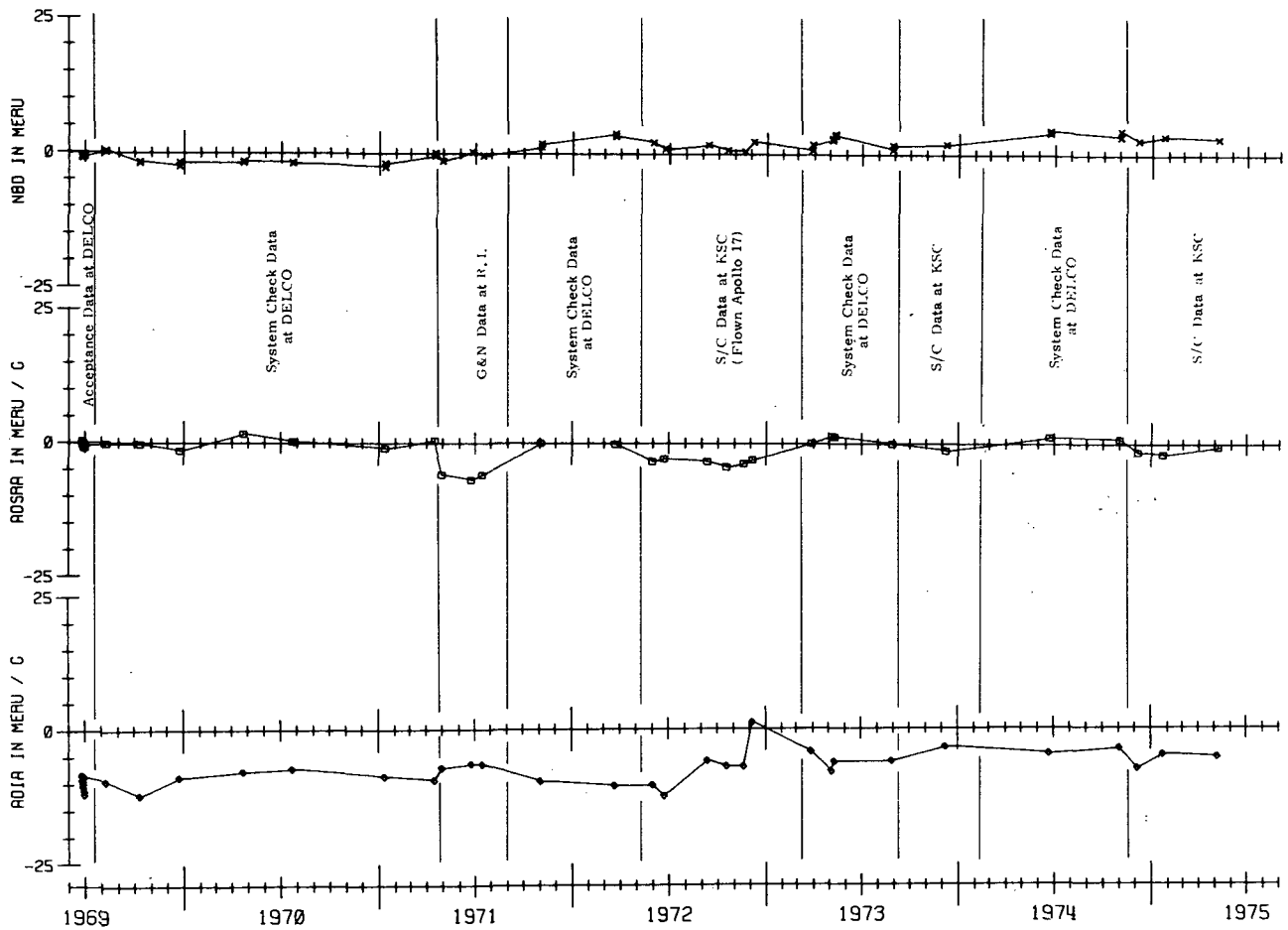
NASA 8A-120

DATE	LOC	TST IMU	GEN	ASSN	SYS	NBD	ADSPR	ADIA	DELSF+	DELSF-	WHEEL ROT HOURS	I+	I-	ID	ADDA
17AU70	A03	SPO	Z	20							1375				
11JA71	A03	SPO	Z	20		2.6		8.7							
11JA71	A03	SPO	Z	20		1.9	1.0				C121	85.018			1.3
12JA71	A03	SPO	Z	20					327	73					
15AP71	A01	SPO	Z	20		0.4		9.4				85.005			1.7
15AP71	A01	SPO	Z	20		0.1	0.5		127	284					
21AP71	IMU	S/N	20		SHIPPED FROM DELCO/MKE TO NR.										
26AP71	IMU	20	GEN	218	INSTALLED IN CM-114.										
29AP71	NSC	GEN	Z	20	218	1.4	5.9	7.1	142	457					
23JE71	NSC	GEN	Z	20	218	0.3	6.9	6.4	285	518					
16JL71	NSC	GEN	Z	20		0.4	6.0	6.5	122	646					
30AU71	IMU	20	SHIPPED FROM NR TO DELCO/MKE.			1.2		9.7							
2NO71	A03	SPO	Z	20		1.8	0.0								2.5
3NO71	A03	SPO	Z	20					94	274		85.003			
29PE72											1621				
21MR72	A03	SPO	Z	20		3.7		10.6							
21MR72	A03	SPO	Z	20		3.2	0.2		417	73		85.009			
30MR72	NO	FLUID TRANSIENT OBSERVED DURING GRAVITY TRANSIENT TEST.													
9MY72	IMU-20	SHIPPED FROM DELCO/MKE TO KSC.													
1RM72	IMU-20	INSTALLED IN CM-114 AT KSC.													
31MY72	K08	GEN	Z	20	218	2.1	3.4	10.4							2.9
22JE72	K08	GEN	Z	20	218	0.9	2.9	12.5	114	280					2.9
11SE72	K9A	GEN	Z	20	218	1.7	3.4	5.9	204	334					2.7
17OC72	K9A	GEN	Z	20	218	0.7	4.4	7.0			1971				2.4
18NO72	K9A	GEN	Z	20	218	0.5	3.8	7.1							2.5
28NO72	PRE-LAUNCH COMPENSATION: NRD=	1.2	ADIA=	-6.0	ADSPR=	-4.0									2.0
5DE72	K9A	GEN	Z	20	218	2.3	3.1	1.2							
6DE72	IMU-20	GEN-218 CM-114 LAUNCHED APOLO 17.									2067				
7DE72															
7DE72	NBD	COMPENSATION UPDATE=	2.7	MRU	AT 23 HRS 45 MIN. GPT										
19DE72	IMU-20	GEN-218 CM-114 RECOVERED. APOLO 17.													
12MR73	IMU-20	SHIPPED FROM NR TO DELCO/SB.													
22MR73	SR6	SPO	Z	20		0.7		4.3	439	124		85.000			
27MR73	SB6	SPO	Z	20		1.8	0.1				C109				
27MR73	SB6	SPO	Z	20							C114				
9AP73	UNIT	REMOVED FROM IMU-20, ASSIGNED TO IMU-25 Z-POS REPL. 9022													
30AP73											2145				
5MY73	SB5	SPO	Z	25		2.7		8.0							
5MY73	SB5	SPO	Z	25		3.0	1.4		40	451		85.003			
10MY73	SB5	SPO	Z	25		3.8		6.2							
10MY73	SB5	SPO	Z	25		3.5	1.2								
11MY73	NO	FLUID TRANSIENTS DETECTED DURING GRAVITY TEST.													
30MY73											2255				1.6
24AU73	SB6	SPO	Z	25		0.9		6.1	432	76		85.003			
27AU73	SB6	SPO	Z	25		1.7	0.1				C120				
27AU73	SB6	SPO	Z	25											
12SE73	IMU-25	MOVED FROM DELCO TO KSC. SL-RESCUE VEHICLE													
24SE73	IMU-25	INSTALLED IN CM-119, GEN-213, SL-RESCUE VEHICLE													

NASA 9A-120

DATE	LOC	TST IMU	GEN	ASSN	SYS	NRD	ADSPA	ADIA	DELSF+	DELSF-	WHEEL ROT HOURS	I+	I-	ID	ADJA
07DE73	KOB	GEN	Z	25	213	1.9	- 1.3	- 3.4	601	- 179					2.9
13PE74	IMU	25	SHIPPED FROM KSC TO DELCO												
21JE74	SB6	SPO	Z	25		4.1		- 4.7	355	- 95	C116	85.003			2.1
21JE74	SR6	SPO	Z	25		4.5	1.2								
1NO74	SR6	SPO	Z	25		3.4		- 3.7	235	- 276		85.001			2.1
1NO74	SB6	SPO	Z	25		4.5	0.8				C124				
18NO74	IMU	25	SHIPPED FROM DELCO TO KSC												
26NO74	IMU	25	INSTALLED IN CM-111												
5DE74	KOB	GEN	Z	25	215	2.7	- 1.6	- 7.6	8	- 438					2.2
22JA75	KOB	GEN	Z	25	215	3.5	- 2.0	- 4.9	7	- 480					2.7
5MY75	K9A	GEN	Z	25	215	3.0	- 0.6	- 5.4	19	- 27					2.5
7MY75															
															2693

G&N 215, CM 111, IMU 25, APOLLO IRIG 8A120, Z AXIS

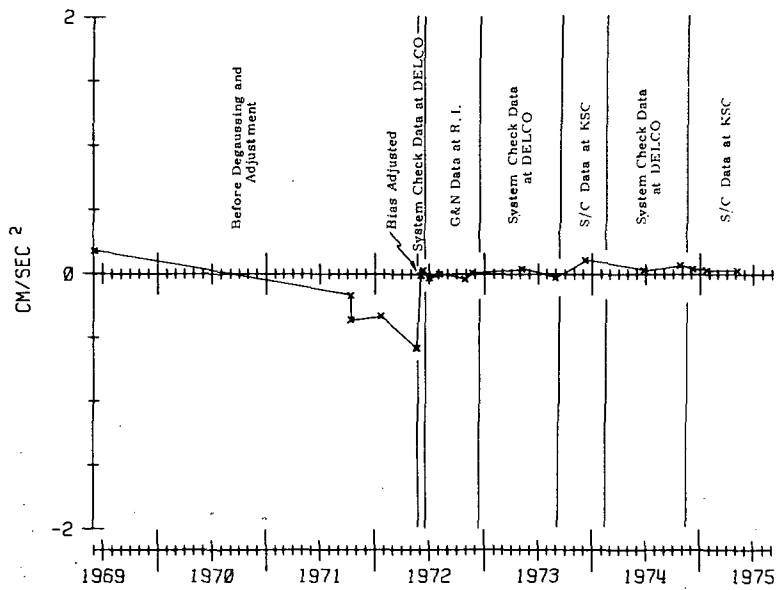


DRIFT PLOTTED BY TIME

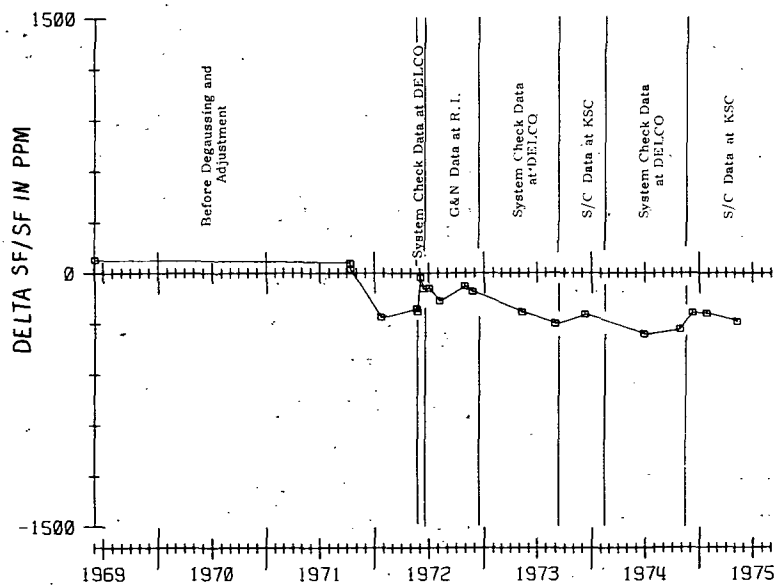
NASA 2AP-110R

DATE	LOC	TST TYP	IMU ASSN	GEN SYS	DELTA SP	IG BIAS	NULL BIAS	ROT-AL-WOB ANGLE	TRANS.	TORQ MCW CURRENT
15JA69	S42	ACC							0.02	104.0500
UNIT INTERNALLY REPAIRED, REBUILT TO P/N 2001730-2										
3JE69	A44	FST			78	0.18		- 8		
11OC71	A48	CRT			58	-0.17	-0.15	- 14	0.05	104.1000
11OC71	A48	CRT					(-0.12)			
12OC71	A48	CRT			20	-0.36	-0.31			104.0985
20JA72	A48	CRT			- 263	-0.33	-0.31		0.02	104.0964
20JA72	A48	CRT					(-0.31)	- 22		
19MY72	A48	CRT			- 210	-0.58	-0.56		0.03	104.1004
21MY72	A48	CRT			- 229	-0.58	-0.55			104.1003
21MY72	A48	CRT					(-0.58)	- 21		
25MY72	UNIT	ASSIGNED TO IMU-25. Y POS. REPLACES 2AP-271.					(-0.57)			104.0907
2JR72	A03	SPO X 25			(- 143)	(-0.64)				
2JE72	RAN EO 3700-NUL	RESOLUTION								
2JE72	A03	SPO X 25			- 27	-0.01	0.02		0.05	104.0917
2JE72	AFTER DEGAUSSING AND ADJUSTMENT									
7JE72	A03	SAL X 25					(-0.04)	10		
9JE72	A03	SPO X 25			- 92	0.03	-0.02	18		104.0935
14JE72	IMU-25	SHIPPED FROM DELCO/MKE TO NR.								
29JE72	NSC GEN X 25 222	- 90	-0.03							
3AU72	NSC GEN X 25	- 165	0.00							
18SE72	IMU-25	REMOVED FROM CM-118 AT NR.								
20CC72	IMU-25	INSTALLED IN CM-119 AT NR.								
27OC72	NSC GEN X 25 213	- 76	-0.04							
21NO72	NSC GEN X 25 213	- 110	0.01							
15DE72	REMOVED FROM CM-119 AT NR.									
19DE72	SHIPPED FROM NR TO DELCO.									
6MY73	SB5 SPO X 25	- 232	0.04				0.07		0.04	104.0967
7MY73	SB5 SAL X 25						(0.03)	11	21	
28AU73	SB6 SPO X 25	- 301	-0.03				-0.02		0.04	104.0971
28AU73	SB6 SAL X 25						(0.01)	8	23	
12SE73	IMU-25	MOVED FROM DELCO TO KSC, SL-RESCUE VEHICLE								
24SE73	IMU-25	INSTALLED IN CM-119, GEN-213, SL-RESCUE VEHICLE								
07DE73	K9B GEN X 25 213	- 246	0.11							
13PE74	IMU 25	SHIPPED FROM KSC TO DELCO					0.02		0.03	104.0900
24JE74	SB6 SPO X 25	- 363	0.03				(0.06)	10	22	
28JE74	SB6 SAL X 25						0.11		0.05	104.0884
23OC74	SB6 SPO X 25	- 331	0.07				(0.12)	7	24	
4NO74	SB6 SAL X 25									
18NO74	IMU 25	SHIPPED FROM DELCO TO KSC								
26NO74	IMU 25	INSTALLED IN CM-111								
05DE74	K9B GEN X 25 215	- 235	0.04							
22JA75	K9B GEN X 25 215	- 240	0.03							
05MY75	K9A GEN X 25 215	- 287	0.03							

G&N 215, CM 111, IMU 25, APOLLO PIPA 2AP110R, X AXIS



1-G BIAS DRIFT PLOTTED BY TIME



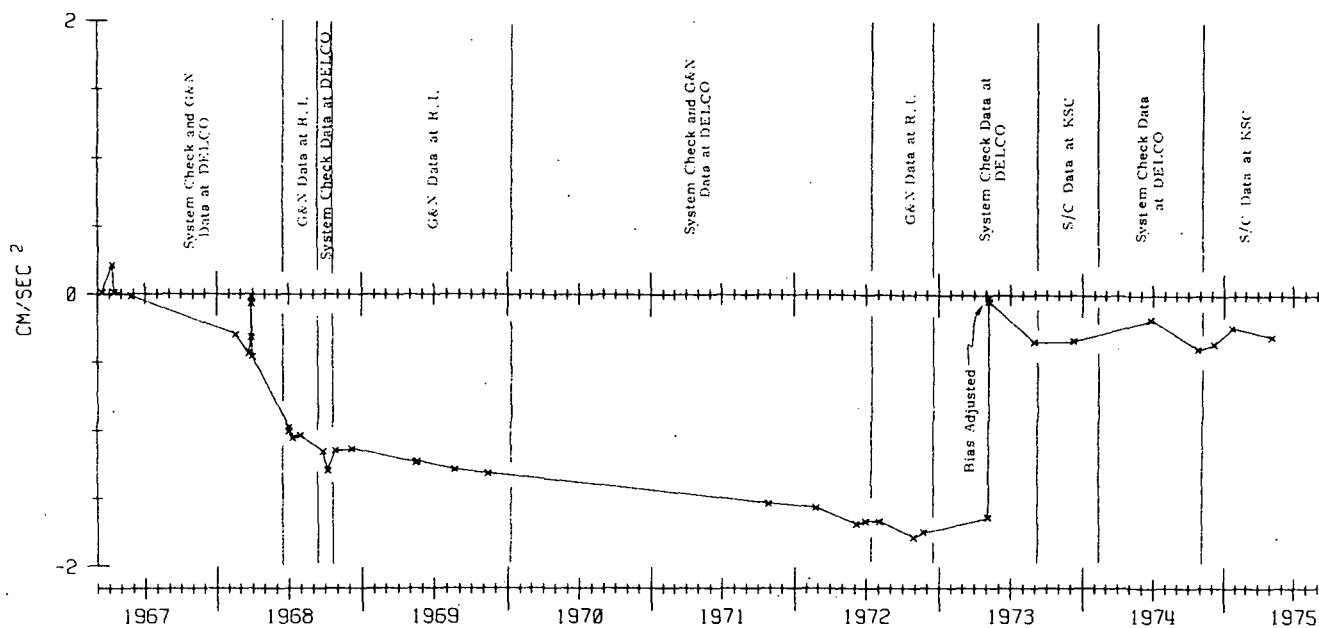
SCALE FACTOR DRIFT PLOTTED BY TIME

21

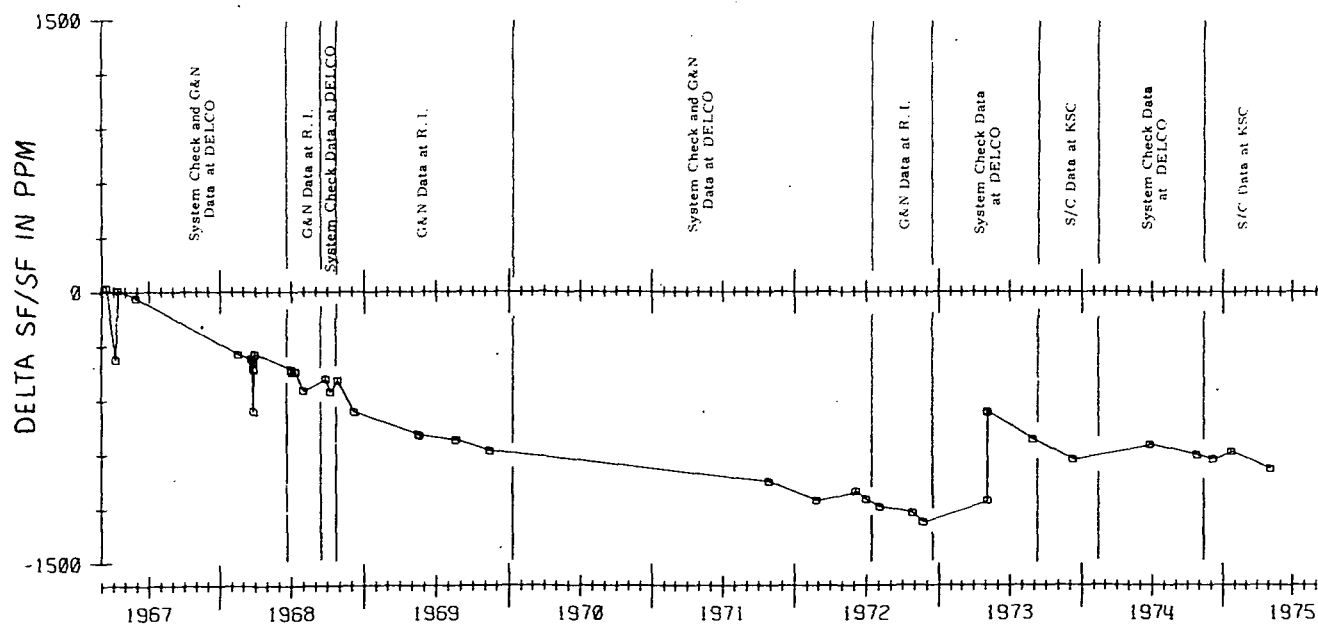
NASA 2AP-276

DATE	LOC	TST	IMU	GEN	DELTA	IG	BIAS	NULL	ROT-AL-WOB	TRANS.	TORQ
		LOC	TYP	ASSN	SYS	SP		BIAS	ANGLE		CURRENT
19DE72	SB5	SHIPPED FROM NR TO DELCO.									
5MY73	SB5	SPO Y 25				-1158	-1.64	-1.64			
5MY73	SB5	APTR ADJUSTMENT									
5MY73	SB5	SPO Y 25				-670	-0.02	-0.05		0.04	105.1437
6MY73	SB5	SPO Y 25				-665	-0.05	-0.03			105.1452
8MY73	SB5	SAL Y 25						(-0.09)	6 - 12		
28AU73	SB6	SPO Y 25				-820	-0.35	-0.32			105.1453
29AU73	SB6	SAL Y 25						(-0.32)	10 - 12	0.04	
12SE73	IMU	-25 MOVED FROM DELCO TO KSC, SL-RESCUE VEHICLE									
24SE73	IMU	-25 INSTALLED IN CM-119, GEN-213, SL-RESCUE VEHICLE									
07DE73	K98	GEN Y 25 213				-929	-0.34				
13FE74	IMU	25 SHIPPED FROM KSC TO DELCO									
25JB74	SB6	SPO Y 25				-848	-0.18	-0.15		0.04	105.1556
28JE74	SB6	SAL Y 25						(-0.26)	11 - 12		
25OC74	SB6	SPO Y 25				-904	-0.40	-0.38		0.05	105.1479
5NO74	SB6	SAL Y 25						(-0.41)	7 - 14		
18NO74	IMU	25 SHIPPED FROM DELCO TO KSC									
26NO74	IMU	25 INSTALLED IN CM-111									
5DE74	KOB	GEN Y 25 215				-929	-0.36				
22JA75	KOB	GEN Y 25 215				-888	-0.24				
05MY75	K9A	GEN Y 25 215				-983	-0.31				

G&N 215, CM 111, IMU 25, APOLLO PIPA 2AP276, Y AXIS



1-G BIAS DRIFT PLOTTED BY TIME



SCALE FACTOR DRIFT PLOTTED BY TIME

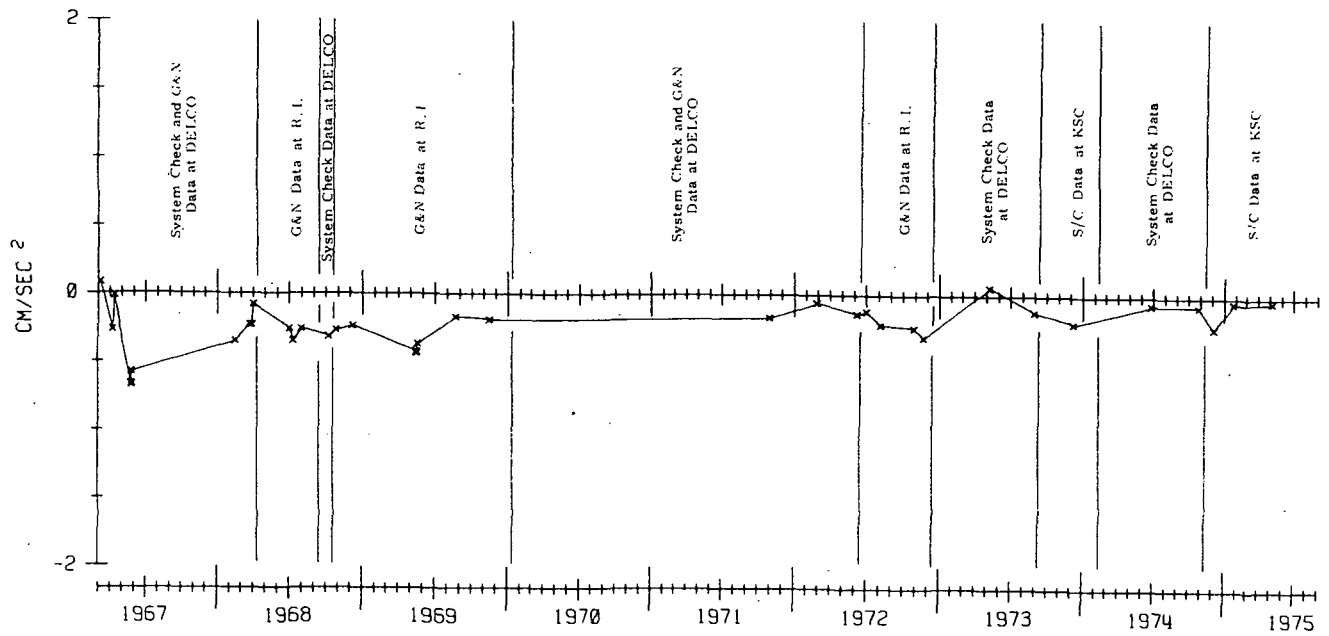
NASA 2AP-292

DATE	LOC	TST TYP	IMU ASSN	GEN SYS	DELTA SP	TG BIAS	NULL BIAS	ROT-AL-WOB ANGLE	TRANS.	TORO MON CURRENT
110C66	S41	ACC			- 96		0.00			103.6342
6NR67	A44	ISA						- 4 - 2		103.6824
6NR67	A44	ISA						- 8 - 3		103.6824
7NR67	A44	PST						- 9 - 6		103.6770
2AP-282 ASSN TO IMU S/N 25, Z										
7AP67	A03	SPR	Z 25		- 39	-0.27	-0.21			103.6815
11AP67	A03	SPR	Z 25		- 9	-0.02	0.06			103.6796
25MY67	A03	SPO	Z 25		- 253	-0.68	-0.59			103.6655
25MY67	A03	SPO	Z 25		- 290	-0.67	-0.59			103.6661
25MY67	A03	SPO	Z 25		- 299	-0.58	-0.45			103.6636
26MY67	A03	SAL	Z 25				(-0.56)	- 4		
16PE68 IMU S/N 25 ASSIGNED TO GEN 212										
16PE68	A03	SPR	Z 25		- 441	-0.35	-0.28			103.6658
21MR68	A01	SPO	Z 25		- 404	-0.21	-0.22			103.6672
21MR68	A01	SAL	Z 25				(-0.25)	0		
27MR68	A01	GEN	Z 25 212		- 417	-0.23				103.6540
27MR68	A01	GEN	Z 25 212							103.6545
27MR68	A01	GEN	Z 25 212							103.6537
30MR68	A01	GEN	Z 25 212		- 317	-0.08				103.6541
IMU S/N 25 SHIPPED TO NR										
11JL68	N06	GEN	Z 25 212		- 370	-0.26				
11JL68	N06	GEN	Z 25 212		- 397	-0.35				
30JL68	N06	GEN	Z 25 212		- 431	-0.26				
23SE68 IMU S/N 25 RETURNED TO AC MKE										
40C68	A03	SAL	Z 25				(-0.26)	- 6		
70C68	A03	SPO	Z 25		- 451	-0.32	-0.30			103.6700
IMU S/N 25 SHIPPED TO NR										
110C68	IMU	S/N	25	215	- 422	-0.27				
250C68	N06	GEN	Z 25 215							
250C68	N06	GAL	Z 25 215					10 - 18		
6DE68	N02	GEN	Z 25 215		- 453	-0.24				
16MY69	NSC	GEN	Z 25 215		- 419	-0.43				
16MY69	NSC	GEN	Z 25 215		- 413	-0.44				
16MY69	NSC	GEN	Z 25 215		- 422	-0.44				
19MY69	NSC	GEN	Z 25 215		- 465	-0.37				
20AU69	NSC	GEN	Z 25 215		- 471	-0.17				
13NO69	NSC	GEN	Z 25 215		- 526	-0.19				
9JA70 IMU S/N 25 SHIPPED FROM NR TO AC/MKE										
280C71	A01	SPO	Z 25		- 551	-0.17	-0.14		0.05	103.6619
1N071	A01	SAL	Z 25				(-0.14)	2		
25PR72	A01	GEN	Z 25 222		- 538	-0.06				
5JE72	A03	SPO	Z 25		- 562	-0.14	-0.11		0.03	103.6609
5JE72 RAN PO 3700-NULL RESOLUTION										
7JE72	A03	SAL	Z				(-0.17)	- 2		
14JE72 IMU-25 SHIPPED FROM DELCO/MKE TO NR.										
29JE72	NSC	GEN	Z 25 222		- 470	-0.12				
3AU72	NSC	GEN	Z 25 222		- 512	-0.22				
18SE72	IMU-25	REMOVED	FROM CM-118	AT NR.						
200C72	IMU-25	INSTALLED	IN C4-119	AT NR.						
270C72	NSC	GEN	Z 25 213		- 463	-0.24				
21N072	NSC	GEN	Z 25 213		- 486	-0.11				

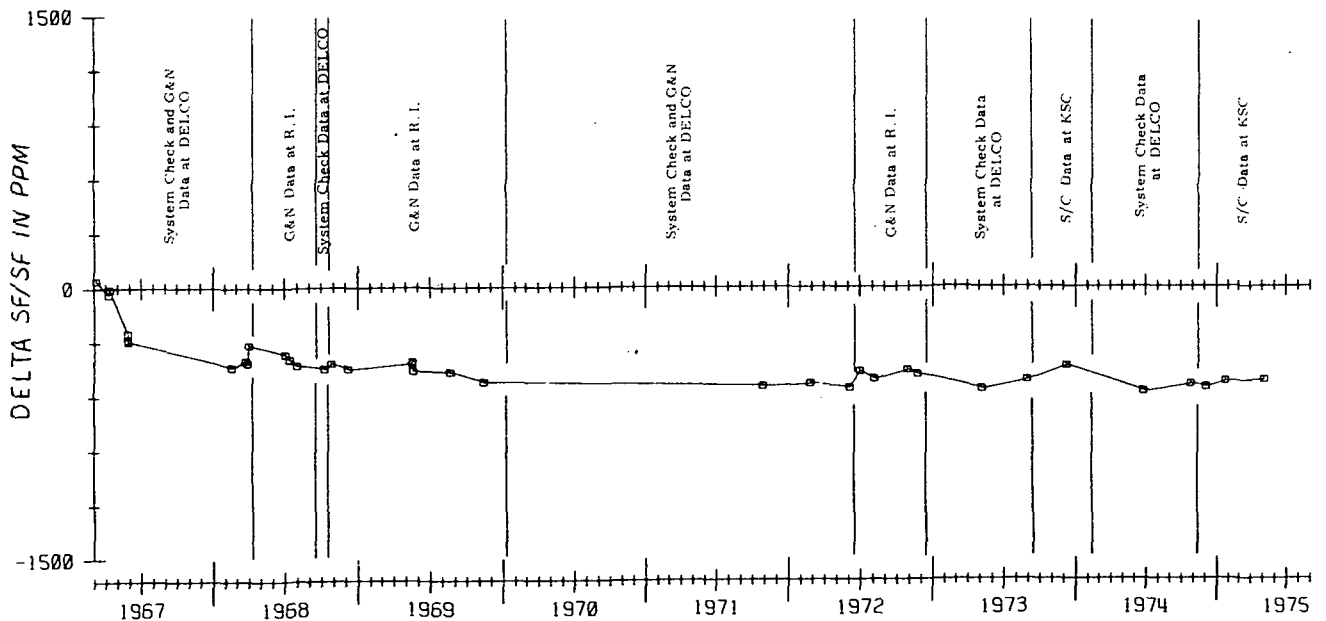
NASA 2AP-2R2

DATE	LOC	LOC	TYP	IMU	GEN	DELTA	IG	PIAS	MULL	ROT-AL-WOB	TRANS.	FORO MON
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15DE72	REMOVED	FROM	CM-119	AT	NR.							
19DE72	SHIPPED	FROM	NP	TO	DELCO.							
7MY73	SB5	SPO	Z	25		- 569	0.06		0.10		0.05	103.6582
8MY73	SB5	SAL	Z	25					(-0.07)	15		
28AU73	SB6	SPO	Z	25		- 519	-0.12		-0.11			103.6527
29AU73	SB6	SAL	Z	25					(-0.15)	5	0.04	
12SE73	IMU-25	MOVED	FROM	DELCO	TO	KSC,						
24SE73	IMJ-25	INSTALLED	IN	CM-119,	GEN-213,	SL-RESCUE						
07DE73	K9B	GEN	Z	25	213	- 440	-0.20					
13PE74	IMU	25	SHIPPED	FROM	KSC	TO	DELCO					
25JE74	SB6	SPO	Z	25		- 583	-0.06		-0.01		0.04	103.6650
28JE74	SB6	SAL	Z	25					(-0.08)	- 2		
25OC74	SB6	SPO	Z	25		- 541	-0.07		-0.05		0.04	103.6633
4NO74	SB6	SAL	Z	25					(-0.02)	3		
1AN074	IMU	25	SHIPPED	FROM	DELCO	TO	KSC					
26NO74	IMU	25	INSTALLED	IN	CM-111							
5DE74	KOB	GEN	Z	25	215	- 559	-0.23					
22JA75	KOB	GEN	Z	25	215	- 526	-0.04					
25MY75	KOB	GEN	Z	25	215	- 520	-0.03					

G&N 215, CM 111, IMU 25, APOLLO PIPA 2AP282, Z AXIS



1-G BIAS DRIFT PLOTTED BY TIME



SCALE FACTOR DRIFT PLOTTED BY TIME

STANDARD DEVIATION (1σ) OF THE IRIG AND PIPA
PARAMETER UNCERTAINTIES USED FOR
MISSION PERFORMANCE SUMMARY
CM 111, IMU 25

PARAMETER

IMU Axis	<u>X</u>	<u>Y</u>	<u>Z</u>
PIPAs			
Data Compilation Period 12/05/74 - 5/05/75			
Accelerometer Bias (cm/sec ²)	0.01	0.06	0.11
Scale Factor (SF/SF ppm)	29	48	21
IRIGs			
Data Compilation Period 12/05/74 - 5/05/75			
Bias Drift (MERU)	0.5	0.9	0.4
ADSRA (MERU/g)	1.9	0.2	0.7
ADIA (MERU/g)	2.8	2.5	1.4
ADOA (MERU/g)	0.1	0.4	0.2

Data is based upon performance in the IMU. Point-to-point stability in operation is much better than the above data.

PROPOSED GYRO AND ACCELEROMETER
PERFORMANCE COMPENSATIONS

PARAMETER

IMU Axis	<u>X</u>	<u>Y</u>	<u>Z</u>
PIPAs			
Accelerometer Bias (cm/sec ²)	+0.03	-0.31	-0.03
Scale Factor (SF/SF ppm)	-290	-980	-520
IRIGs			
Bias Drift (MERU)	+0.7*	+1.6	+3.0
ADSRA (MERU/g)	+3	-5	-1
ADIA (MERU/g)	+22	-13	-5

* Compensation selected as NBD -ADOA

Dictionary of Terms

ACC	Acceptance Test Data
ACD	After Cooldown
ACE	A. C. Electronics (presently Delco Electronics)
ADJ	Adjusted
ADOA	Acceleration Sensitive Drift Due to Acceleration along the OA
BCSW	Binary Current Switch
BIA	Bias Adjusted
BUSS	High, Low, or Nominal Direct Current Test
CDN	Post Cooldown
CQL	Component Qualification
CRQ	Component Requalification
CRR	Retest after Minor Adjustment or Resistor Changes
CRT	Retest Data
CSS	Short Servo Test
CVR	Component Verification
DGI	Degaussed IRIG
DGS	Degaussed
F/F	Float Freedom
FST	Final Stability
GAL	Guidance & Navigation PIPA Alignment
G&N	Guidance & Navigation System Measurement
GP	Gaussed PIPAs
HBS	Hi Bus Voltage
I&A	Inspection and Acceptance
ISS	Inertial Subsystem Data
KSC	Kennedy Space Center
LBS	Lo Bus Voltage
MW	Milliwatt
NAR	North American Rockwell (presently Rockwell International, Inc.)
NBS	Nominal Bus Voltage
OOS	Out of Spec
RDT	Wheel Rundown Time, Seconds
RI	Rockwell International

APPENDIX

ELECTRICAL POWER REQUIREMENTS

This section was extracted from the MIT/IL Report E-1142 (Rev. 59) "SYSTEM STATUS REPORT". It is included in this report for convenience.

Electrical power and energy reporting is based upon the inflight spacecraft sequence of events for the Design Reference Mission as developed by the Apollo Mission Planning Task Force (AMPTF). (Reference GAEC Report Volume III - LED-540-12, dated October 30, 1964).

The accompanying diagrams present the power drawn through the spacecraft circuit breakers. It is assumed that power is drawn from the spacecraft's primary +28VDC supply and a 400 cps-115 VAC single-phase inverter.

Intermittent power peaks can exist, particularly during operation of displays and controls at random times. The energy content in these peaks is considered negligible.

All values (except those mentioned above) are actual expected levels of power at 28.0 VDC. They are based on measured values on G&N systems 207 and 208 for the Block II Command Module. No margin factor has been applied to protect against possible differences between G&N systems and spacecrafts. Thus, these values should not be taken as "not to exceed" extremes.

The following Interface Control Documents serve as the guidelines for reporting power figures.

CM Block II MH01-01327-216 "G&N Electrical Input Power" signed 15 July 1965.

BLOCK II GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC COMMAND MODULE

BASED UPON 198.5 HOURS (8.27 DAY) LUNAR ORBIT MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

REFERENCE GANC REPORT - LED 540-12, 30 OCTOBER 1964
APOLLO MISSION PLANNING TASK FORCE

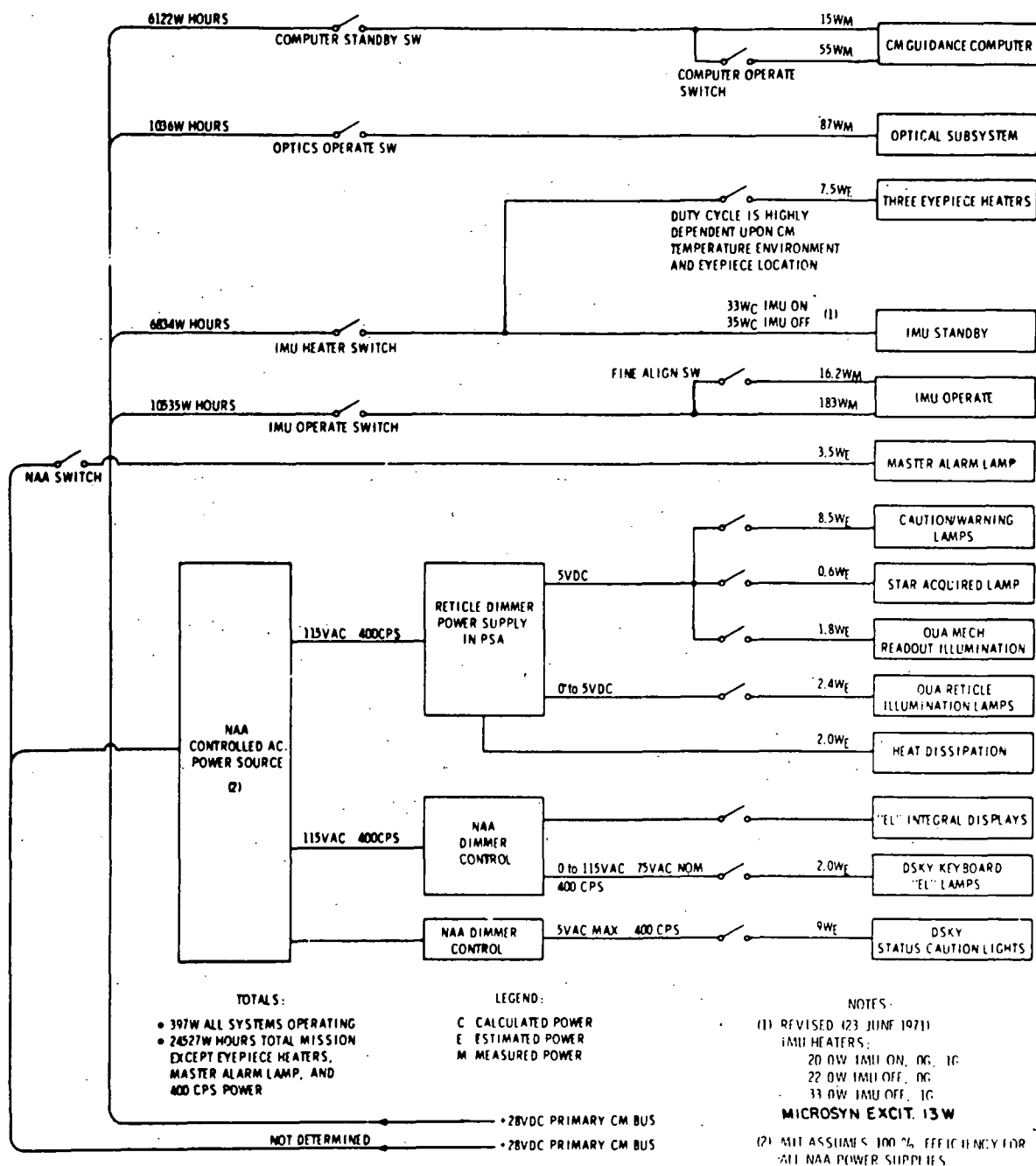


Figure A-1

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